EXERCISE TESTING IN HYPERTENSION PATIENTS

Zhaohui Meng [1], Jing Bai [1], Shuqi Cui [2], Suzhong Wang [2]
[1]Department of Electrical Engineering, Tsinghua University, Beijing, P. R. China
[2]Department of Preventive Medicine, Capital University of Medical Science, Beijing, P. R. China

Abstract- **In china, hypertension becomes a dangerous factor to the public health in recent years. To study its impact on health status, an exercise testing was developed to examine the change of physiological parameter. 107 hypertension patients and 68 healthy persons were volunteers for this testing. During testing, ECG, pulse wave, respiratory wave and blood pressure were recorded. According to the parameters measured, the WHOQOL-BERF results completed by all subjects, and the evaluation based on the physical function, statistical analysis was carried out using Student's t-test and Logistic Regression. The results show that recovery time of BP, maximal systolic pressure, and the score of physical function could be used to reflect the difference between hypertension patients and healthy persons. In conclusion, the Logistic Regression model could be used to detect hypertension status by the exercise testing which did not depend on the sphygmomanometer merely.**

Keywords- **Hypertension, exercise testing**

I. INTRODUCTION

In China, the morbidity rate of hypertension was 5.11% in 1959. This rate has increased to 11.26% in 1991. And the hypertension is the risk factor for cerebral apoplexy, coronary heart disease and heart failure to Chinese people now [1].

But in most cases, sphygmomanometer is the only instrument to deduce hypertension, which is not very accurate, because the BP (blood pressure) is accessible by many factors, such as mood, season and occupation. So it is very important to study the method for hypertension diagnosis.

In this work an exercise testing for hypertension patients was carried out using our Assistant of General Practitioner system [2], which could measure multi-channel physiological parameters synchronistically and continuously including ECG, respiratory wave, and pulse wave during the exercise testing. At the same time, BP (diastolic pressure, systolic pressure, and mean pressure) could be also measured. All data obtained from this system would be saved in digital form and managed by a database.

Overall health status can be evaluated through the QOL (Quality of Life) questionnaire [3][4]. In order to distinguish the quantitative difference of the health status between the hypertension patients and healthy persons, all of the subjects completed the WHOQOL-BERF (Chinese Version) before the exercise testing.

According to the daily mobility, existing symptoms and physiological adaptability, physical function of the subject was evaluated with score between 0 and 100.

The goal of this research is to obtain the quantitative relationship of physiological parameters, the results of WHOQOL-BREF, and physical function between the observation group (hypertension patients) and the control group (healthy persons).

II. METHODOLOGY

A. Exercise Testing

The BP level is correlative with the morbidity of cardiovascular disease [1], and the cardiovascular system is regulated by autonomic nervous system. So the cardiovascular system of hypertension patients may be in disorder. The exercise testing scheme is adopted for the compatibility of sympathetic and parasympathetic nervous system [5][6][7].

107 hypertension patients were selected at SanLiHe hospital in Beijing, who had the hypertension history over two years and were asked not to take drug for two days before the exercise testing. And 68 healthy volunteers at China Capital University of Medical Science took the exercise testing as the control group.

Each subject was asked to sit down and take a rest for about five minutes while the ECG, respiratory wave and pulse wave were measured. At the same time, the subject completed the WHOQOL-BREF and the physical function questionnaire, and the form of general information, including age, sex and etc. All information collected was inputted into the database.

At the relaxation state, the signals were recorded. The BP was recorded with an interval of 90 seconds. And the time of BP measurement was marked in the recording. After three times BP measurement, the subject was asked to take the stair-climbing exercise. The stair step was 15 cm high. The subject needed to step on the stair, and then get down right after that. This process was kept about one minute and the signals were recorded for the whole period. Then the subject sat down and the signals and BP were recorded until they returned to the resting level (the BP was still recorded about every 90 seconds.). The duration of whole exercise testing was about 15 minutes.

B. Data collection

In the exercise testing, about 7 or 8 groups of BP were recorded. Fig.1 illustrates the trend of BP change. Similar conditions were observed in other testing.

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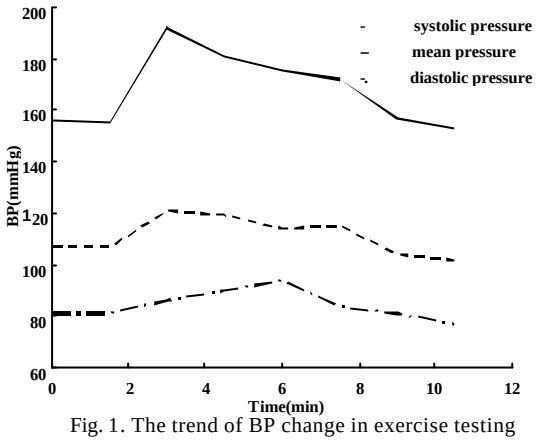

Fig. 1. The trend of BP change in exercise testing

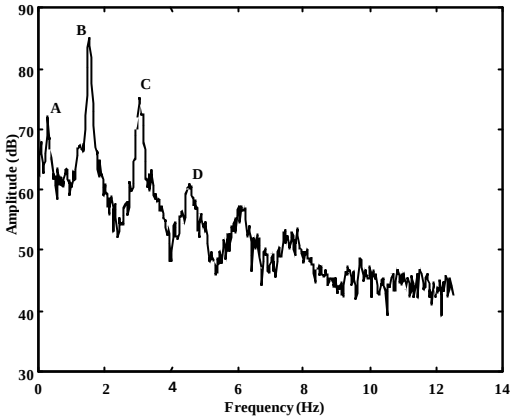

Fig. 2. The frequency spectrum of pulse wave

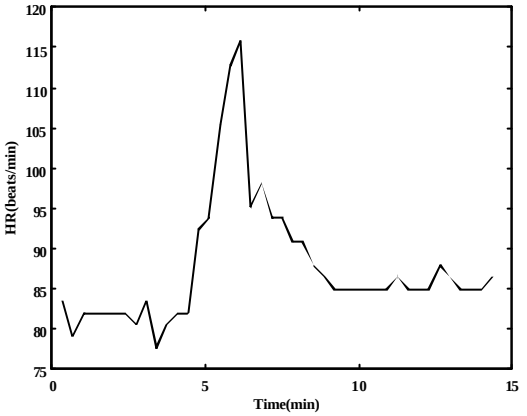

Fig. 3. HR in exercise testing

The trend indicates that systolic pressure (P_s) and mean pressure (P_m) increased during the stair-climbing exercise and decreased when the exercise finished, and at last they returned to the rest level. But there was no obvious relation between the diastolic pressure (P_d) and the exercise. It suggests that diastolic pressure was not affected by the exercise.

P_m can usually be approximated satisfactorily from P_d and P_s as follows.

$$P_m = P_d + \frac{1}{3}(P_s - P_d) \qquad (1)$$

The mean pressure can be regarded as the linear combination of the systolic pressure and diastolic pressure. The feature was reflected during the exercise process.

Thus, only the systolic pressure was selected as the index to reflect the BP regulation process during exercise testing.

The resting systolic pressure (RSP) and maximal systolic pressure (MSP) could be estimated from the data shown in Fig. 1. The recover time of BP (RTBP) was calculated as the interval between the time reaching MSP and recovering to RSP using the time of BP measurement.

HR was not measured directly in this case, but it could be obtained from the ECG or pulse wave. Pulse wave was selected to calculate the HR because ECG was affected more easily than pulse wave by the noise due to the movement during the exercise.

The pulse wave signal was divided into the sections of 20 seconds, which contained about 4096 bits. Making used of FFT, the HR could be obtained from frequency spectrum of pulse wave duration.

As shown in Fig. 2, point A, B, C, and D represented the respiration rate (RR), HR, and the higher harmonics of HR. Thus HR could be obtained through the maximal point (y-axis) in Fig. 2. As a result shown in Fig. 3, there were about 30 HR values estimated in the whole testing process, and which were used to determine the recovery time of HR (RTHR). This method was similar to the method for calculating RSP, MSP and RTBP.

Finally the data contained in database, including following four parts.

a. Motive function parameter: RSP (mmHg), MSP (mmHg), RTHR (second) and RTBP (second).
b. The results of WHOQOL-BREF questionnaire (Chinese Version): Physical Domain (PHD), Psychological Domain (PSD), Social Relations Domain (SRD) and Environment Domain (ED).
c. Physical function parameter (SF): daily mobility, existing symptoms, and physiological adaptability.
d. The general information: age, sex, smoke (YES/NO), drink (YES/NO) and the Self-evaluation.

C. Statistical Analysis

Difference between the physiological parameters of observation group and the control group was estimated by Student's t-test as the single-variate analysis. In order to develop clinical indexes for hypertension, Logistic Regression analysis was adopted as multivariate analysis method to determine the relative weights associated with each predictor variable used in the final model.

Analysis was performed with SPSS 10.0 for Windows. All calculated p values were two-tailed. Levels of significance for all tests was defined by $p<0.05$.

III. RESULTS

In a total, exercise testing of 107 hypertension patients (61.1%) and 68 healthy persons (48.9%) were completed. General characters of the subjects were summarized in Table I.

The average age was 58.19 ± 10.80 for the observation group and 42.38 ± 16.48 for the control group. And the two groups had no significant difference in Sex (42 males and 65 females in observation group while 29 males and 39 females in control group). In the four domain of WHOQOL-BERF, there was statistically significant difference in physical domain (p=0.01) and environment domain (p=0.01), and no statistically significant difference in psychological domain (p=0.84), social relations domain (p=0.89) and self-evaluation domain (p=0.42).

The mean value of RTHR was 104.53 ± 31.55 seconds for the observation group and 83.21 ± 31.82 seconds for the control group. And the mean value of RTBP was 338.01 ± 59.83 seconds for the observation group and 234.38 ± 71.90 seconds for the control group. These two parameters had statistically significant difference between two groups also. Significant difference was observed in RSP and MSP, too.

Therefore the items taken into the multiple Logistic Regression analysis were: Age, PHD, ED, SF, RTHR, RTBP, RSP and MSP.

Table II shows the results of the multiple Logistic Regression analysis. The independent variables selected by the forward Stepwise method were SF, RTBP and MSP. And the percentage correct was 81.0%.

TABLE I
RESULTS OF WHOQOL-BERF AND EXERCISE TESTING

Characters	Patient with hypertension	Healthy person	p-value
Number	107	68	
Age	58.19 ± 10.80	42.38 ± 16.48	0.00*
Sex (Male=0)	0.61 ± 0.49	0.57 ± 0.50	0.66
PHD	64.32 ± 13.04	70.42 ± 10.49	0.01*
PSD	62.91 ± 12.17	62.56 ± 8.56	0.84
SRD	69.43 ± 12.60	69.71 ± 11.25	0.89
ED	62.30 ± 13.02	55.39 ± 12.14	0.01*
Self-evaluation	81.43 ± 11.01	82.81 ± 10.61	0.42
SF	71.43 ± 15.13	84.87 ± 12.54	0.00*
RTHR (sec)	104.53 ± 31.55	83.21 ± 31.82	0.00*
RTBP (sec)	338.01 ± 59.83	234.38 ± 71.90	0.00*
RSP (mmHg)	131.70 ± 15.79	120.73 ± 10.63	0.00*
MSP (mmHg)	155.90 ± 20.59	139.80 ± 13.85	0.00*

*: P<0.05

The PHD, PSD, SRD, ED, Self-evaluation and SF were scored as centesimal system.

TABLE II
RESULTS OF MULTIPLE LOGISTIC REGRESSION

	BETA	P-VALUE.	ODD RATIOS
SF	-.069	.001	.933
RTBP	.024	.000	1.024
MSP	.035	.036	1.036
Constant	-6.572	.022	.001

IV. DISCUSSION

Hypertension is correlative with the diseases of cardiovascular system that is regulated by autonomic nervous system. During the exercising testing the function of sympathetic nerve and parasympathetic nerve will be more active than that in the resting state.

As shown in Fig. 1, diastolic pressure had little change during the exercise testing. It seemed that the exercise testing almost did not affect the diastolic pressure.

From the results of multiple Logistic Regression, no result of WHOQOL-BREF questionnaire was in the final model. It is understandable because the results of WHOQOL-BREF depend on the career, mood and mentality of the subject that is hard to determine as accurately as the ECG and BP. As a result, the variables selected by SPSS were SF, RTBP, and MSP. These parameters can be measured directly and objectively.

The WHOQOL-BREF questionnaire is easy to use and can be completed without professional medical staff. As shown in Table I, the PHD and SD had statistically significant difference between hypertension patients and healthy persons. Thus, the WHOQOL-BREF questionnaire also has its usefulness in this study.

In the application of the Logistic Regression, we took the hypothesis that the relation among the physiological parameters was linear for the purpose of making the model simple. In fact the physiological system is complicated and nonlinear. Nonlinear analysis method should be developed to replace of the Logistic Regression in the future.

V. CONCLUSION

This paper introduces an exercise testing scheme. It was used to find the characteristic physiological parameters to discriminate the hypertension patients and the healthy persons.

We analyzed the data recorded in the exercise testing, the results of WHOQOL-BREF questionnaire, and the evaluating physical function using Student's t-test and Logistic Regression method.

In conclusion, the physical function (SF), the recovery time of BP (RTBP), and the maximal systolic pressure (MSP) were found to be the characteristic parameters to discriminate the hypertension patients and the healthy persons.

The Logistic Regression model provides a simple and reliable method to evaluate the healthy status related with hypertension.

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